COURSE STRUCTURE FOR M.TECH. ELECTRICAL ENGINEERING(POWER SYSTEMS)
SEMESTER II

w.e.f. 2016-2017

Sr. No	Course Code	Course Name	Teaching Scheme					Exam Scheme					
								Theory			Practical		Total
			L	T	P	C	Hrs/wk	MS	ES	IA	LW	LE/Viva	Marks
1	EE 506	Modern Control Systems	3	0	0	3	3	25	50	25	--	--	100
2	EE 507	Power System Analysis and Dynamics	3	0	0	3	3	25	50	25	--	--	100
3	EE 508	Advanced Power Electronics	3	0	0	3	3	25	50	25	--	--	100
4	EE 509	Advanced Digital Signal Processing	3	0	0	3	3	25	50	25	--	--	100
5	EE 510	Laboratory-II	0	0	4	2	4	--	--	--	50	50	100
6	EE 5xx	Department Elective	3	0	0	3	3	25	50	25	--	--	100
7		Open Elective II	3	0	0	3	3	25	50	25	--	--	100
8		Successful Research and Development Program	2	0	0		2						NP/PP
		Total	**20**	**0**	**4**	**20**	**24**	150	300	150	50	50	700

MS = Mid Semester, ES = End Semester; IA = Internal assessment (like Test/quizzes, assignments etc.)
LW = Laboratory work; LE = Laboratory Exam

Department Elective
EE 511 Smart Grid Technologies and Applications
EE 512 EHV AC and HVDC Transmission

List of Open Electives (C2) (FOET Level)		
Sr. No.	**Open Elective I (Sem I)**	**Open Elective II (Sem II)**
1	ME 512 Finite Element Method	CE 568 Finite Element Method
2	CE 514 Geographical Information Systems	EN 513 Environmental Impact Assessment
3	EN 502 Air Pollution Modelling, Monitoring and Control	CE 525 Earthquake Engineering
4	NE 511 Introduction to quantum and statistical Mechanics	MA 511 Operation research
5	ME 513 Renewable Energy and Energy Management	ME 516: Solar Thermal Systems
6	SE 505 Renewable Energy and Energy Management (Solar)	EE 513 Control Motors
7	EN 506 Atmospheric Process & Climate Change (Chemical/Science)	
8	EN 504 Environmental Legislation	
9	EE 505 Renewable Energy Systems	

Department Elective

EE 511 Smart Grid Technologies and Applications

EE 512 EHV AC and HVDC Transmission

EE 506 Modern Control Systems										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **11**

ANALYSIS OF CONTROL SYSTEMS IN STATE SPACE: Concept of state and state space, state and output equations, state variable representations, canonical realizations, solution of state equations, Concepts of controllability and observability.

UNIT II **11**

STATE VARIABLE ANALYSIS OF DIGITAL CONTROL SYSTEMS: Discretisation of continuous time state equation, discrete time state equations, solution of discrete state space equations, Controllability to the origin and reachability.

UNIT III **08**

DESIGN OF MODERN CONTROL SYSTEMS: Pole placement design through state feedback, stability improvement by state feedback, state regulator design, Design of state observer and state estimator, Quadratic optimal regulator design.

UNIT IV **09**

MODEL PREDICTIVE CONTROL: Different models used in MPC, Dynamic Matrix Control, Optimal Control filtering, Linear Kalman Filters, EKF

TOTAL HOURS **39**

Text and References:

1 C.T.Chen, "***Linear system theory and design***", Oxford, 3rd Edition

2 K. Ogata, "***Modern Control Engineering***", PHI, 4th Edition

3 M. Gopal, "***Digital Control and State Variable Methods***", TMH, 3rd Edition

4 John Bay, "***Fundamentals of linear state space systems***", McGraw Hill

5 Wilson Rugh, "***Linear system theory***", Prentice Hall, 2nd edition

6 Thomas Kailath, "Linear systems", Prentice Hall International

7 B.C.Kuo, "Automatic Control System".

EE 507 Power System Analysis and Dynamics										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **05**

NETWORK FORMULATION AND GRAPH THEORY: Introduction, Network Equations, Graph Theory, Development of Network Matrices from Graph Theoretic Approach, Augment Cut set Incidence Matrix Cut set and Circuit Equations, Building Algorithm for the Bus Impedance Matrix Modification of Z_{BUS} matrix due to changes in the primitive network

UNIT II **15**

GENERATOR MODELING - I (MACHINE VIEWPOINT): Classical Machine Description, Voltage Generation, Open-Circuit Voltage, Armature Reaction, Terminal Voltage, Power Delivered by Generator, Synchronizing Generator to an Infinite Bus, Synchronous Condenser, Role of Synchronous Machine Excitation in Controlling Reactive Power.

GENERATOR MODELING – II (CIRCUIT VIEWPOINT): Energy Conversion, Application to Synchronous Machine, The Park Transformation, Park's Voltage Equation, Park's Mechanical Equation, Circuit Model, Instantaneous Power Output, Applications, Synchronous Operation, Steady-state Model, Simplified Dynamic Model, Generator Connected to Infinite Bus (Linear Model).

UNIT III **12**

EXCITATION AND PRIME MOVER CONTROLLERS: Excitation System requirements, Elements of an Excitation System, types of Excitation System – AC/DC excitation, Static excitation system, Modelling of excitation system.

ANALYSIS OF SINGLE MACHINE SYSTEM: Small Signal Analysis with Block Diagram Representation, Characteristic Equation (CE) and Application of Routh-Hurwithz Criterion, Synchronizing and Damping Torque Analysis, Small Signal Model: State Equation, Nonlinear Oscillations – Hopf Bifurcation.

UNIT IV **07**

ANALYSIS OF MULTI-MACHINE SYSTEM: Simplified system Model, Detailed models: Case I, Detailed models: Case II, Inclusion of Load and SVC dynamics, Modal Analysis of Large Power Systems, Case Studies.

TOTAL HOURS **39**

Text and References:

1 Vijay Vittal, "***Power Systems Analysis***", Bergen, Pearson Education

2 K R Padiyar, "***Power System Dynamics***", B S Publications

3 P.Kundur, "***Power System Stability & Control"***, Tata Mcgraw hill

4 L. P. Singh, "***Advanced Power System Analysis and Dynamics",*** New Age International Ltd, New Delhi

EE 508 Advanced Power Electronics										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **08**

REVIEW OF POWER SEMICONDUCTOR DEVICES: Review of Power semiconductor devices, Gate and Base drive circuits - Preliminary design considerations, Temperature control of power devices.

DESIGN CONSIDERATIONS Design and selection of magnetic components, inductor, high-frequency transformers, line and EMI filters, Heat sink design, IEEE 519 (1992) considerations

UNIT II **12**

FLEXIBLE AC TRANSMISSION SYSTEMS: Principle of power transmission, Principle of shunt compensation, Shunt compensators: Thyristor controlled reactor, Thyristor switched capacitor, Static VAR compensator, Advanced static VAR compensator. Principle of series compensation, Series Compensators: Thyristor switched series capacitor, Thyristor controlled series capacitor, Force commutation controlled series capacitor, Series static VAR compensator. Principle of phase angle compensation, Phase angle compensator, Unified Power Flow Controller, Comparisons of compensators.

UNIT III **13**

Matrix Converter, Vector control, Indirect and direct vector control, various grid connected inverters, Multilevel inverters: Concept, Diode-Clamped, Flying-Capacitor, Cascaded type multilevel inverters, Features and comparison

UNIT IV **6**

APPLICATIONS OF POWER ELECTRONICS: Unity power factor conversion, Control of wind generators, active filters, photovoltaic applications, maximum power point tracking

TOTAL HOURS **39**

Text and References:

1 N.Mohan, T.M. Undeland&W.P.Robbins, "***Power Electronics: Converter, Applications & Design"***, John Wiley & Sons

2 R. Bausiere& G. Seguier, "***Power Electronic Converters",*** Springer- Verlag

3 D.M.Mitchell, "***DC-DC Switching Regulator Analysis"***, McGraw Hill

4 B. JayantBaliga, ***"Fundamentals of Power Semiconductor Devices"***, Springer

5 Web-Resources: *https://**ieee**xplore.**ieee**.org*

6 N.G.Hingorani&Gyugyi***, "Understanding Facts",*** Standard Publishers

7 K.R.Padiyar, ***"FACTS Controller in Power Transmission & Distribution",*** Anshan Ltd.

EE 509 Advanced Digital Signal Processing										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **10**

Introduction to Discrete Time Signals and Systems: Introduction, Classification of signals, Sampling of analog signals, Brief review of Sampling Theorem, Reconstruction of Signals, and Concept of Aliasing using frequency domain representation, Discrete time signals, Discrete time systems.

Frequency Spectra and DFT: Frequency analysis of discrete time signals, Frequency domain and time domain signal properties, Fourier transform properties for discrete time signals, Discrete Fourier Transform, Properties of DFT, Frequency analysis of signals using DFT.

UNIT II **10**

COMPUTATIONAL ACCURACY IN DSP IMPLEMENTATIONS: Number formats for signals and coefficients in DSP systems, Dynamic Range and Precision, Sources of error in DSP implementations. **ARCHITECTURES FOR PROGRAMMABLE DSP DEVICES:** Basic Architectural features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External interfacing.

EXECUTION CONTROL AND PIPELINING: Hardware looping, Interrupts, Stacks, Relative Branch support, Pipelining and Performance, Pipeline Depth, Interlocking, Branching effects, Interrupt effects, Pipeline Programming models.

UNIT III **09**

PROGRAMMABLE DIGITAL SIGNAL PROCESSORS: Commercial Digital signal-processing Devices, Data Addressing modes of TMS320C6000 DSPs, Memory space of TMS320C6000 Processors, Program Control, TMS320C6000 instructions and Programming, On-Chip Peripherals, Interrupts of TMS320C6000 processors, Pipeline Operation of TMS320C6000 Processors.

UNIT IV **10**

INTERFACING MEMORY AND I/O PERIPHERALS TO PROGRAMMABLE DSP DEVICES: Memory space organization, External bus interfacing signals, Memory interface, Parallel I/O interface, Programmed I/O, Interrupts and I/O, Direct memory access (DMA). A Multichannel buffered serial port (McBSP), McBSP Programming.

TOTAL HOURS **39**

Text and References:

1 Sanjit K Mitra, "***Digital Signal Processing: A computer-based approach***", Tata McGraw Hill

2 Phil Lapslay, "***DSP Processor Fundamentals***", IEEE Press

3 Alan V. Oppenheim, Ronald W. Schafer, "***Discrete-Time Signal Processing***", PHI

4 John G. Proakis, and Dimitris G. Manolakis, "***Digital Signal Processing***", PHI

5 Avtar Singh and S. Srinivasan, "***Digital Signal Processing***", Thomson Publications

6	B. VenkataRamani and M. Bhaskar, "***Digital Signal Processors, Architecture, Programming and Applications***", TMH
7	Jonatham Stein, "***Digital Signal Processing***", John Wiley

Successful Research and Development Program										
Teaching Scheme					Examination Scheme (audit course)					
L	T	P		Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
2	0	0		2				--	--	(Pass/fail)

The Research Organization: Objectives & Goals of a Research Organization, Components of a research organization, Contracting & Operational Support Activities, Indirect Support Activities, Di rect Support Activities, Costs & Infrastructure Accounting, General & Administration Activities, Market & Business Development Activities, Profit & Non-Profit Entity Implications, Business Case for R&D, R&D Structures & Costs for Selected Industry Segments, Success stories.

Research Staff: Research & Academic Faculty, Scientists & Technologists**,** Research Associates**,** Graduate Students**,** Visiting Researchers**,** Employment Laws, Contracts, & Implications**,** Workplace Regulations.

Sponsors & Funding Agencies: Funding Agencies – Types**,** Types of Interface with Funding & Sponsor Agencies**,** Call for Proposals & Opportunity Tracking**,** Types of Proposals & Grants**,** Contracting Vehicles & Arrangements**,** Deliverables, Interim & Final Reviews**,** Cost & Performance Audits**,** Contract Laws & Enforcement**,** Ethics & Lobbying**,** Conflict of Interest & its Management.

Proposals for Research Program Funding: Center & Consortia Proposals**,** Individual Principal Investigator Proposals**,** Continuation & Renewal Proposals**,** Prime/Subcontractor Relationships & Contracting**,** Cost Accounting**,** Laws and Regulations**.**

Research Program Contracts: Types of Contracts – IDIQ, Cost-Sharing, Cost-Plus, Intellectual Property & Patent Laws**,** Export Control & Arms Regulations Compliance**,** Academic versus Commercial Contracts**,** Technology Transfer**,** Overhead & Indirect Costs**,** Federal & Government Cost & Accounting Regulations (FAR)**,** Case Studies.

Writing a Successful Research Proposal: Technical Proposal, Management Proposal, Cost Proposal, Technology Proposal, Statement of Work & Deliverables, Case Studies.

The Research Process – I: Steps in development of successful research program, Quality and Cost consideration, Laboratories and infrastructure setup, Staffing & Support Models, Peer-Review, Independent Verification & Validation, Internal & External Review processes, Ethics & Regulatory Laws & Guidelines, Case Studies.

The Research Process – II: Problem Definition**,** Background Study**,** Valuation & Current Practice**,** Proposal Writing**,** Deliverables & Timelines Development**,** Results Projection**,** Staffing, Costs & Progress Tracking**,** Quality Management**,** Publication & Patents**,** Intellectual Property & Licensing**,** Technology Transfer**,** Validation & Test.

Deliverables & Audits: Technical Reports**,** Software**,** Hardware**,** Systems**,** Qualification**,** Cost Reports**,** Test Reports**,** Papers & Publications**,** Patents**,** Case Studies**.**

Department Elective

EE 511 Smart Grid Technologies and Applications										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I **08**

INTRODUCTION TO SMART GRID: Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid, Present development & International policies in Smart Grid. Case study of Smart Grid ,CDM opportunities in Smart Grid

UNIT II **15**

SMART GRID TECHNOLOGIES: Introduction to Smart Meters, Real Time Pricing, Smart Appliances, Automatic Meter Reading (AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Home & Building Automation, Phase Shifting Transformers, Smart Substations, Substation Automation, Feeder Automation. Geographic Information System(GIS), Intelligent Electronic Devices(IED) & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, Wide Area Measurement System(WAMS), Phase Measurement Unit(PMU)

UNIT III **06**

MICRO GRIDS AND DISTRIBUTED ENERGY RESOURCES: Concept of micro grid, need & applications of micro grid, formation of micro grid, issues of interconnection, protection & control of micro grid. Islanding, need and benefits, different methods of islanding detection.

UNIT IV **10**

POWER QUALITY MANAGEMENT IN SMART GRID: Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Power Quality Audit.

INFORMATION AND COMMUNICATION TECHNOLOGY FOR SMART GRID: Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network (NAN), Wide Area Network (WAN). Bluetooth, Zig-Bee, GPS, Wi-Fi, Wi-Max based communication, Wireless Mesh Network, Broadband over Power line (BPL)

TOTAL HOURS **39**

Text and References:

1 Ali K., M.N. Marwali, Min Dai, "***Integration of Green and Renewable Energy in Electric Power Systems"***, Wiley

2 Clark W. Gellings, "***The Smart Grid: Enabling Energy Efficiency and Demand Response***", CRC Press

3 JanakaEkanayake, N. Jenkins, K. Liyanage, J. Wu, Akihiko Yokoyama, "***Smart Grid: Technology and Applications***", Wiley

4 Jean Claude Sabonnadiere, NouredineHadjsaid, "***Smart Grids***", Wiley Blackwell

5	Tony Flick and Justin Morehouse, "***Securing the Smart Grid***", Elsevier Inc.
6	Peter S. Fox-Penner, "***Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities***", Island Press

Open Elective II

EE513 Control Motors										
Teaching Scheme					Examination Scheme					
L	T	P	C	Hrs/Week	Theory			Practical		Total Marks
					MS	ES	IA	LW	LE/Viva	
3	0	--	3	3	25	50	25	--	--	100

UNIT I

Servomotors

Servo system, Requirements of a good servomotor, Types of servomotors, DC Servomotors Basic operating principle, Field controlled dc servomotor, Armature controlled dc servomotor, Characteristics and applications of dc servomotors. **10**

UNIT II

AC Servomotors **06**

Construction, types of rotors, Operating principle, Torque/Speed characteristics, Applications of AC Servomotors.

12

UNIT II

Stepper Motors

Terms used in step motors, Types of stepper motors, Various modes of operation of Variable reluctance motors, micro stepping control of stepper motor, Multistack VR stepper motor, Construction and working of PM stepper motor and hybrid stepper motors, Torque/speed characteristics of the stepper motor.

09

UNIT IV

Single phase and special purpose motors

Universal motor, AC Series motors, starting and speed control of single phase induction motors, Repulsion motors, Reluctance and hysteresis motors, Brushless dc motors.

TOTAL HOURS 39

Text and References:

1 T.J.E. Miller, "Brushless Permanent Magnet and Reluctance motor drives", Clarendo Press, oxford.

2 V.V. Athani, "Stepper Motors: Fundamentals, applications and Design", Mc Graw Hill

3 Y. Dote and S. Kinoshita, "Brushless Servomotors-Fundamentals and applications", Clarendo Press, oxford.

4 A.E. Fitzerald, Charles Kingsley and Stephen D Umans, "Electric Machinery", TMH Publication.